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The Process of Turbocharging a Car Engine

Since the early 1960's people have been installing turbochargers on cars in order to maximize the amount of power that is produced by the engine. While originally designed for use on aircrafts, a turbocharger (turbo) can be added to almost any internal combustion engine to dramatically increase the output power.

Essentially, a turbo is nothing more than an air compressor that works with the fundamental principles of an engine in order to create more power. To function properly, an engine needs to create a perfect ratio of air to gas inside of a cylinder before that mixture is ignited by the spark plug and the energy is converted. In order to better describe turbocharging, think of an engine as a large air pump. The amount of air in each cylinder determines the amount of gasoline that can be added which directly correlates with the amount of power produced. This means that the more air is pushed through the engine, the more power can be produced. A turbocharger uses this idea by compressing the incoming air which allows for more air to fit inside the cylinder ultimately allowing more power to be created by the same engine.

Parts of Turbocharged System

The simple idea behind a turbocharger allows it to be added on most cars using only a few parts and modifications. Looking at the specific function of each of these parts will help describe the overall process of turbocharging. These components are often split into two categories: exhaust and intake.

Turbo Exhaust Manifold

On a non-turbo car, the exhaust manifold is the part that collects the exhaust gasses from each cylinder and combines them into a single exhaust pipe. For a turbocharged car, these gasses must be collected and pushed through the turbine of the turbo. In order to do this, the exhaust manifold is replaced with a turbo exhaust manifold. Rather than collecting the gasses to a single pipe, the turbo exhaust manifold has a flange on it that a turbine can be bolted to allowing the exhaust gas to flow through the turbo. The manifold is usually made out of high strength stainless steel as it will commonly see high temperatures from the exhaust and must support the turbo while heated.

Turbine

The turbo itself can be split into two halves consisting of the turbine and compressor. The turbine is connected as part of the exhaust and is often referred to as the hot side of the turbo. When heated exhaust gasses are pushed through the turbine it spins a shaft that is connected to the compressor on the other end. This rotational force is where the system gets the energy to compress the incoming air. Once the exhaust goes through the turbine it then continues through the rest of the stock exhaust system of the car.

It’s worth noting here that the only difference between a turbocharger and a supercharger is where the energy comes from to compress the air. While a turbo is driven by harnessing the left over energy in the exhaust gas, a supercharger is driven by some mechanical connection to the motor such as a belt and pulley.

Compressor

The compressor works in the opposite way as the turbine as it pulls air through it when the shaft is being driven. Once there are enough exhaust gasses flowing, the turbine is able to spin the compressor fast enough to pressurize the air entering the engine. Since there is now more air entering the engine that creates more exhaust exiting the engine which in turn drives the compressor even faster. To prevent this cycle from continuing until failure, the compressor is fitted with a device called a wastegate to limit the pressure. The figure below depicts how both halves of the turbo function together in unison.

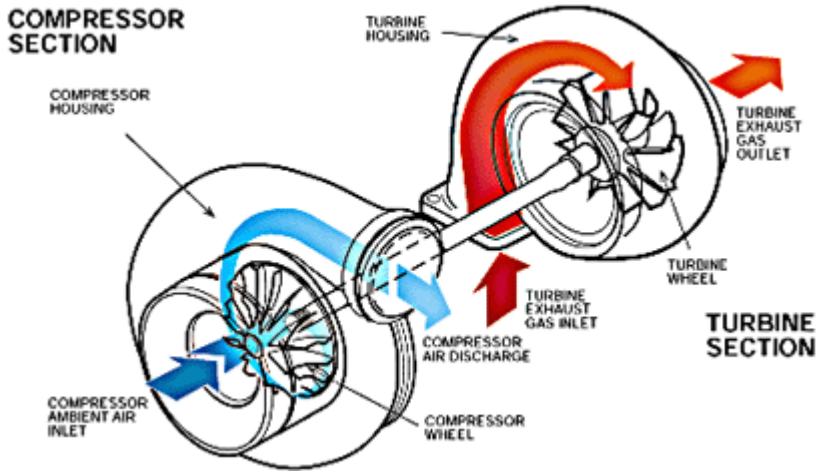

Figure 1: Turbine and Compressor

Intercooler

Once the incoming air is pressurized by the compressor it tends to heat up due to the laws of physics. Since the objective of the turbocharger is to get the most amount of air inside the engine, cooling this air will increase its density and allow for more air to enter each cylinder at a time. To achieve this cooling, the pressurized air is passed through what’s called an intercooler or charged air cooler. An intercooler is essentially a radiator designed to cool air as it absorbs the heat from the air on in inside and disperses this heat to the air around it through aluminum fins. The intercooler is an important part of any turbocharged system as it helps to maximize the efficiency of the turbocharger without adding any additional moving parts.

Engine Management

The final and most important part of a turbocharged system is communicating with the engine control unit (ECU) and encoding how to handle the increase in air pressure. This is the most difficult part of turbocharging a car as it needs to be customized for not only the engine, but for different parts used in the turbocharged system. This is also the most risky part of installing a turbocharger as any slight miscalculations can cause the air-fuel ratios to be incorrect which can lead to destroying the engine. There are several different engine management systems available and they can be chosen based off of the intended power goals of the setup. Regardless of which one is used, any engine management system is going to require extensive amounts of fine tuning in order to get the engine running properly. The overall objective is to fool the ECU into adding more fuel to the engine based off the amount of pressure created by the turbo.

Summary and Conclusion

Now that you know the different parts required to turbocharge an engine, it is easy to see all the different tasks performed by this system simultaneously. The figure below will help to better visualize how all of the different components work together.

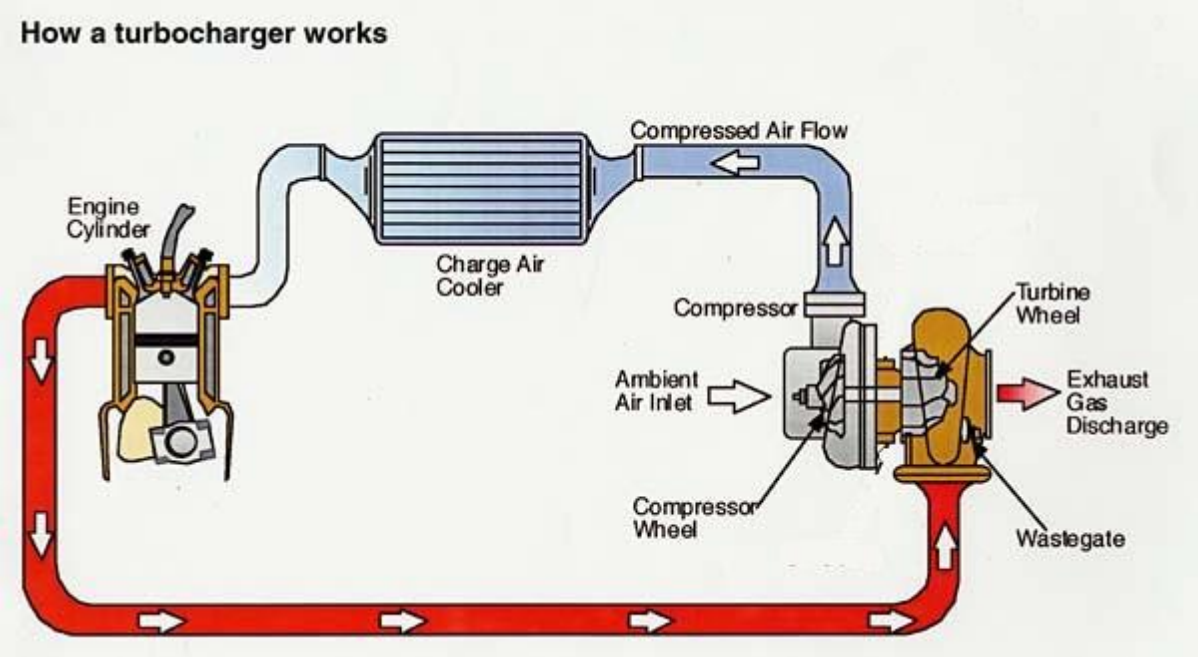

Figure 2: How a Turbocharger Works

From this diagram it is easy to see how the energy from the flowing exhaust gas spins the turbine which then drives the compressor to pressurize the air flowing through the intercooler and into the engine. The turbo exhaust manifold is not pictured in this diagram, but it would replace the red pipe connecting the engine cylinder to the turbine. The engine management system is missing from this figure as well because it is often car specific and nearly impossible to generalize. Lastly, keep in mind that this is an extremely simplified description of a turbocharger and extensive amounts of research should be done before attempting to add this to an engine.